

To: File for controlled ground water area petition 43C-30006730

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DNRC Water Management Bureau

Date: October 29, 2007

Subject: DNRC Comments on the Hydrology Report for the Proposed Horse Creek Controlled Groundwater Area

Summary

The purpose of this review is to comment on a report dated October, 10 2007 that was prepared by HydroSolutions, Inc. to provide the results of studies conducted during the period of the Temporary Horse Creek Controlled Ground Water Area (CGWA). HydroSolutions includes ground-water level and spring hydrographs, water quality data, water use and water right information in their report. The focus of their analysis is their argument that withdrawals from the Horse Creek drainage which comprises approximately 1/3 of the temporary CGWA and 1/5 of the proposed extended CGWA greatly exceeds recharge to that area. They provide only general discussion regarding the remainder of the CGWA and limited justification of the expanded boundary.

The area of potential impact for new ground-water withdrawals is the area that needs to be evaluated under §85-2-506 MCA. That area would include the proposed expanded CGWA boundary plus aquifer boundaries that include the limit of alluvium along Grove Creek to the west, West Rosebud Creek to the southeast and east and the Stillwater River to the north. HydroSolution states that analysis of the Horse Creek drainage separate from the rest of the CGWA is justified because ground-water divides generally coincide with the surface drainage. I disagree, because ground-water divides are unrelated to the area that withdrawals from wells affect. Drawdown from wells expands in all directions toward the aquifer boundaries and their effects within the Horse Creek drainage will be a fraction of their total effects within the current or proposed expanded CGWA.

I believe HydroSolutions has underestimated recharge. First, equating recharge to change in ground-water level ignores the nearly simultaneous effect of recharge on aquifer discharge. Basically, it takes more water to fill an aquifer to a certain level if it leaks out the sides than if it is surrounded by impermeable boundaries or is distant from discharge boundaries. Second, recharge that may follow a longer flow path and, therefore does not result in seasonal ground-water level fluctuations is ignored. Last, infiltration from Grove Creek where it crosses the outcrop of the Tullock aquifer along the western edge of the CGWA is not considered.

HydroSolutions does not account for water that returns to the aquifer during irrigation and through septic drainfields. I believe this water should properly be subtracted from the estimate of ground water withdrawals. HydroSolutions also includes in their estimate of ground-water withdrawals discharge to Horse Creek and springs, subirrigation, and stock use from surface water or springs. All these represent natural discharge from the aquifer

system or a use of surface water. In the past, these discharges and surface water uses have not been part of the calculations of ground-water withdrawals under §85-2-506 MCA, and do not appear to fall within the meaning of “ground-water withdrawals.” From my calculations, total net ground-water withdrawal within the Horse Creek drainage, including full build-out of Crow Chief Meadows Subdivision, is 5 percent of recharge within the expanded CGWA boundary using the recharge rate estimated by HydroSolutions. There are a handful of additional domestic wells within the existing and proposed expanded CGWA, but outside of the Horse Creek drainage that are not accounted for in my calculation. Even adding the additional small withdrawals, total withdrawals will be less than 5 percent using a more appropriate estimate of recharge.

Visual inspection of hydrographs of ground-water levels in the current CGWA indicate that ground-water levels respond to significant rain events, but generally did not decline during the period of record. Instead, I believe the primary effect of expanded ground-water development within the current or proposed expanded CGWA will be to decrease discharge to springs and surface waters including Horse Creek, West Rosebud Creek and the Stillwater River. As long as the new ground-water withdrawals do not exceed or approach the rate of recharge, water levels in wells may not decline significantly because of their close proximity to discharge boundaries and the rapid expansion of drawdown to those discharge boundaries.

Controlled Ground Water Area Criteria

§85-2-506(2)(a) MCA: Ground-water withdrawals are in excess of recharge to the aquifer or aquifers within ground-water areas

HydroSolutions states, after reviewing water rights in the Horse Creek watershed, that “it is readily seen that the demand for groundwater and surface water far exceeds recharge estimates presented in this report”. I disagree with this conclusion for the following reasons.

1. the analysis includes natural discharge to springs, surface water, and subirrigation as ground-water withdrawals

Discharges to springs, surface water, and subirrigation are natural discharges from the aquifer and have not in the past been considered ground-water withdrawals under §85-2-506 MCA. The fact that water discharges from the aquifer system is clear evidence that withdrawals do not exceed recharge.

2. the analysis is limited to the Horse Creek drainage

By limiting their analysis to the Horse Creek drainage, HydroSolutions treats that portion of the aquifer system as disconnected from the remainder of the current or proposed expanded CGWA. Actually, the aquifer is not bounded at the drainage divides of Horse Creek or ground-water divides (that HydroSolutions state are similar to the drainage divides). The effects of ground-water withdrawals from the Tullock Aquifer beneath the Horse Creek drainage will expand to aquifer boundaries in all directions and not be

limited to that area. Ultimately, ground water withdrawals are offset by reduced discharge from springs and seepage to surface water from within and at the boundary of the entire proposed expanded CGWA.

3. the estimate of recharge presented in the HydroSolutions report appears to be underestimated

HydroSolutions estimates recharge from average seasonal rise in ground-water levels and aquifer storativity for a confined aquifer. This approach ignores the dynamic relationship between ground-water levels and discharge at springs and streams, and recharge that does not vary seasonally because it follows a longer flow path and does not vary seasonally. In addition, HydroSolutions does not consider losses from Grove Creek over subcrops of the Tullock aquifer along the western edge of the CGWA where it is a potentially important source of recharge.

In general, recharge water initially increases aquifer storage until it is offset by increased discharge in a similar fashion to the inverse effects of pumping a well described by Theis (1940). Overall, recharge is equal to the change in ground-water storage plus increased discharge. Water level rise may be a good indicator of recharge during the early stages of a seasonal recharge event when water is accreting solely to ground-water storage and discharge is constant. However, water level rise is a poor indicator of recharge once discharge begins to increase as a result of the water-level rise caused by recharge. Hydrographs of ground-water levels and springs from within the CGWA, show that recharge events raise ground-water levels and increases spring discharge almost simultaneously. HydroSolutions states in their report that all springs react quickly to significant precipitation events. Therefore, equating recharge to change in ground-water storage results in an underestimate of recharge, probably by a significant degree, because of the rapid equilibration of increased discharge associated with recharge events within the CGWA. This increased discharge can be captured (as defined by Lohman (1972)) to offset added ground-water withdrawals, essentially regulating the effects of ground-water withdrawals from wells.

HydroSolutions argues that recharge is limited to outcrops of the Tullock and Tongue River members of the Fort Union Formation because the underlying Hell Creek Formation is considered a confining layer. The Lebo member between the Tullock and Tongue River members also is considered a confining layer. There is no evidence presented to indicate that the mapped fault does not cross the Hell Creek Formation confining layer and potentially feed water from deeper formations as it does the Lebo member confining layer. Seepage upward along the fault from aquifers in the Judith River or Eagle formations the outcrop southwest of the current and proposed expanded CGWA may contribute additional water to the Tullock and Tongue River aquifers. The seasonal variations of this recharge will be dampened and will not be reflected in ground-water level fluctuations and, therefore, would not be counted in the recharge estimate by HydroSolutions.

Alluvium of Grove Creek is in contact with outcrops or subcrops of the Tullock member along much of the western boundary of the CGWA. HydroSolutions identifies an outcrop of the Hell Creek Formation in one area; however Grove Creek clearly is in contact with the Tullock member along the west side of the CGWA. Infiltration from Grove Creek directly to the Tullock aquifer seems to be a better explanation of rapid response of ground-water levels during major rain events instead of percolation through the Lebo member confining layer.

4. the estimate of withdrawals appears to be significantly inflated

HydroSolutions appears to significantly overestimate net withdrawals from the CGWA as follows:

- HydroSolutions assumes existing domestic use equals an average annual rate of 5 gpm per household for four existing wells for a total of 20 gpm. In addition, HydroSolutions assumes use in Crow Chief Meadows subdivision is 100 gpd per person with four persons per household. Typical domestic use is 50 to 75 gallons per day (gpd) per person based on research in Colorado (Kimsey and Flood, 1987) and household sizes in the census blocks that includes the CGWA are 2.5 persons or less. Research in Colorado also indicates that 88 to 98 percent of water diverted for domestic use is returned to the aquifer through septic drainfields. Therefore, the amount of consumption for in-house uses is not very sensitive to variations the amount of water pumped. Using 187.5 gpd per household, typical domestic use is 22.5 gpd per household or 0.016 gpm on average annually (0.025 ac-ft per year). Using this value the total domestic consumptive use for four existing homes is 0.06 gpm (0.10 ac-ft per year) and the total domestic consumption for 65 homes in Crow Chief Meadows at full build is 1.02 gpm (1.64 ac-ft per year).
- Withdrawals for lawn and garden irrigation are estimated by HydroSolutions to be 37.31 inches. This estimate is based on 36 inches consumptive demand, 12.7 inches seasonal precipitation, 5 inches leaching fraction, and 70 % efficiency. HydroSolutions does not provide references for these values. In contrast, the Montana Irrigation Guide (U.S. Soil Conservation Service, 1987) for the Columbus weather station (the closest station to the CGWA included in the guide) lists consumptive use for pasture grass equal to 24.06 inches with a net irrigation requirement of 14.01 inches derived using the Blaney Criddle method. The weather station at the Billings Wastewater Treatment Plant is the nearest station with data for turf grass in the Montana Irrigation Guide. For the Billings station, consumptive use for turf and pasture grass is 26.25 inches and net irrigation requirement is 19.73 inches for Turf and 16.08 inches for pasture grass. I estimated Net irrigation requirement for turf at the Columbus station to be 17.64 inches by extrapolating data for turf and pasture grass for Columbus and Billings. The main difference between the estimate from the Irrigation Guide and the estimate by HydroSolutions is that HydroSolutions includes a leaching fraction and an estimate of efficiency to determine total withdrawals, both components that return to the aquifer and are not consumed. Subtracting these components brings the HydroSolutions estimate to 23.3 inches, a value closer to that provided in the Montana Irrigation Guide. For further comparison, the water

diversion standard in ARM 36.12.115 for lawn and garden permitting is 2.5 ac-ft per acre. This equates to 21 inches net irrigation requirement assuming 70% efficiency.

- Stock water use from springs has not been considered a ground-water withdrawal under §85-2-506 MCA. Nonetheless, the guideline for stock water consumption for permitting in ARM 36.12.115 is 15 gallons per day (2.97 gpm average use and 4.79 ac-ft annual volume for 285 AU) compared to 30 gallons per day used by HydroSolutions (5.94 gpm average use and 9.58 ac-ft annual volume for 285 AU).
- Subirrigation is natural discharge from the aquifer and, therefore has not been considered a ground-water withdrawal under §85-2-506 MCA. Nonetheless, evidence of piezometer water levels within the Crow Chief Meadows subdivision indicate that subirrigation during summer is limited to approximately 9 acres in the vicinity of piezometer P5 and DNRC flume #1. Subirrigation of 9 acres will consume on average 5.58 gpm compared to 13.0 gpm estimated for 20.9 acres by HydroSolutions.
- Flows in Horse Creek and measured springs included by HydroSolutions in their estimate of withdrawals are surface water and surface water flows have not been considered ground-water withdrawals under §85-2-506 MCA. Including these flows as ground-water withdrawals appears to be counter to the purpose of the criteria that “ground water withdrawals are in excess of recharge to the aquifer or aquifers within the ground-water area”.

My calculations of net withdrawal are summarized in Table 1. The estimate of average annual total ground-water consumption for 65 homes in the Crow Chief Meadows Subdivision each with 0.2 acre lawn and garden irrigation and 2.5 persons using 75 gpd in-house is 12.9 gpm (20.8 ac-ft annually) compared to total subdivision demand of 43.2 gpm (69.9 ac-ft annually) estimated by HydroSolutions. Total net ground-water withdrawal for all 69 homes within the Horse Creek drainage is estimated to be 13.7 gpm (22.0 ac-ft annually) compared to 63.2 gpm (101.9 ac-ft annually) estimated by HydroSolutions. Total net withdrawal within the Horse Creek drainage including full build out of Crow Chief Meadows using my calculations (13.7 gpm or 22 ac-ft) is 24 percent of recharge calculated by HydroSolutions (58 gpm). Total net withdrawal within the Horse Creek drainage using my calculations, including full build-out of Crow Chief Meadows Subdivision, is 5 percent of recharge within the expanded CGWA boundary using HydroSolutions estimated recharge rate of 0.71 inches per year (275.1 gpm over 7,500 acres). I did not calculate the percentage of withdrawals outside Horse Creek relative to recharge within the proposed expanded CGWA boundary; however there are limited additional withdrawals (as I have defined withdrawals) within the current or proposed expanded CGWA boundary and outside the Horse Creek drainage.

Table 1. Estimates of ground-water withdrawals from Horse Creek drainage within Horse Creek CGWA.

Use	Diverted	Consumed	DNRC Estimate Net Withdrawal	HydroSolutions
Domestic outside Crow Chief	4 X 188 gpd	4 X 23 gpd	0.06 gpm	20 gpm
Lawn and garden outside Crow Chief	4 X 375 gpd	4 X 262 gpd	0.73 gpm	
Subtotal outside Crow Chief			0.8 gpm	20 gpm
Domestic within Crow Chief	65 X 188 gpd	65 X 23 gpd	1.02 gpm	18.1 gpm
Lawn & garden within Crow Chief	65 X 375 gpd	65 X 262 gpd	11.85 gpm	25.1
Subtotal inside Crow Chief			12.9 gpm	43.2 gpm
Total for all Horse Creek Drainage			13.7 gpm	63.2 gpm

§85-2-506(2)(b) MCA: Excessive ground water withdrawals are very likely to occur in the near future because of consistent and significant increases in withdrawals from within the ground water area

HydroSolutions did not address the potential that excessive ground-water withdrawals are likely to occur in the near future. The following are my observations.

The primary effect of expanded ground-water development within the CGWA will be to decrease discharge to springs and surface waters including Horse Creek, West Rosebud Creek and the Stillwater River; however this concern does not appear to be addressed under §85-2-506 MCA.

The rapid response of ground-water levels and spring discharge to precipitation events is evidence of how drawdown from future wells in the Tullock Aquifer will propagate. Drawdown from additional wells also should expand rapidly to the boundaries of the aquifer because of the close proximity of the boundaries and the low storativity of the aquifer. Theis (1938, 1940) states the basic principle that pumping from a well initially obtains water from aquifer storage, but eventually equilibrium between recharge and discharge is reestablished by reducing discharge or increasing recharge at aquifer boundaries (e.g. springs, surface water, wetlands). In the case of the Horse Creek current and proposed expanded CGWA, recharge and discharge from the aquifer system should adjust to a new equilibrium to new pumping rapidly and effects on ground-water levels will be minimized because of the close proximity of any wells to discharge boundaries and the rapid expansion of drawdown to those discharge boundaries. In addition, extensive additional withdrawals appear unlikely because 77 percent of the current CGWA and 72 percent of the proposed expanded CGWA outside of the Crow Chief Subdivision is owned by petitioners or the State of Montana.

§85-2-506(2)(d) MCA: ground water levels or pressures in the area in question are declining or have declined excessively

HydroSolutions analyzed ground-water level data to obtain estimates of recharge and for comparison to precipitation; however they did not provide detailed analysis of water-level trends. Visual inspection of hydrographs provided in the report indicate that ground-water levels respond to significant rain events, but generally does not indicate ground-water levels have declined during the period of record. Of the two wells with the longest period of record, the hydrograph for the Chandler well (Figure 7) has no overall trend and the hydrograph for the Witt well (Figure 8) has a slight upward trend. Ground-water levels may be regulated by fluctuations in discharge to springs and surface waters in response to fluctuating recharge and, as a result, might not respond significantly to long-term rainfall deficits.

Conclusions

- Neither the Horse Creek drainage divide nor ground water divides define the area of potential impact of wells and appears to be an inappropriate basis for evaluating criteria under §85-2-506 MCA. The expanded CGWA is delineated by aquifer boundaries and a more logical area for evaluating the criteria.
- Stream-flow loss from Grove Creek as it crosses the outcrop of the Tullock aquifer is likely an important source of recharge to the current and proposed expanded CGWA in addition to infiltration of precipitation and should be considered.
- Equating recharge to change in ground-water levels underestimates recharge as a result increased discharge associated with recharge events within the current and proposed expanded CGWA.
- Equating recharge to change in ground-water levels ignores recharge that follows longer flow paths from outcrops of deeper aquifers that does not vary seasonally.
- The HydroSolutions report appears to overestimate ground-water withdrawals by not accounting for diverted water that returns to the aquifer and by including flows in Horse Creek and springs, subirrigation, and stock use from surface water and springs.
- Total withdrawals in the Horse Creek Drainage, including full build out of Crow Chief Meadows Subdivision, are approximately 5% of recharge.
- Equilibrium between recharge and discharge from the aquifer system should rapidly adjust to new ground-water uses that do not approach the rate of recharge and effects on ground-water levels will be minimized because of the close proximity to discharge boundaries.
- The primary effect of expanded ground-water development within the CGWA will be to decrease discharge to springs and streams including Horse Creek, however effects on discharge to springs and surface water have not been addressed under §85-2-506 MCA previously.

References

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